WINTER ABUNDANCES OF RED-TAILED AND RED-SHOULDERED HAWKS IN FLORIDA: AN ANALYSIS OF CHRISTMAS BIRD COUNT DATA, 1946-1983

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ABSTRACT.—Audubon Christmas Bird Counts indicate that winter abundances of Red-tailed (*Buteo jamaicensis*) and Red-shouldered (*B. lineatus*) hawks declined in Florida in the early 1950's. From the mid-1950's through 1983, numbers reported for Red-shoulders showed no directional trend, but numbers of Red-tails gradually increased to levels as much as ten times those of the mid-1950's. Though variations in weather and locations of the counts affect apparent abundance of these hawks, such effects cannot account entirely for the increase in Red-tail numbers. Heightened reproductive success or suitability of Florida habitats may explain the Red-tail increase.

Data from Audubon Society Christmas Bird Counts (hereafter CBCs) have been recognized as a useful tool for determining long-term trends in bird abundances (Raynor 1975). Here I report results of an analysis of CBC data for two common Florida hawks: the Red-tailed Hawk (*Buteo jamaicensis*) and the Red-shouldered Hawk (*B. lineatus*).

METHODS

The following data were gathered from Audubon Field notes (vol. 1-25) and American Birds (vol. 26-38) for each Florida CBC reported from 1946 to 1983: latitude, longitude, number of Red-tailed Hawks, number of Red-shouldered Hawks, total party-hr, total party-km, and weather. Following Brown (1972), weather on the count day was classified as either clear or overcast from the descriptions published with each CBC. In a few of the earlier CBCs, weather or party-km was not reported; these CBCs were omitted only from analyses requiring the missing information. Offshore counts also were omitted.

To investigate the possible effects of late autumn weather preceding the CBCs, I also tabulated mean temperatures for November and December of each year 1950-1980 from Climatological Data (Asheville, North Carolina: NOAA, vol. 1-31) for stations at Orlando, Florida; Atlanta, Georgia; Raleigh, North Carolina; and Philadelphia, Pennsylvania. These locations were chosen arbitrarily from among many possibilities to represent a range of latitudes on the eastern U.S. coastal plain. Thus, I assumed that most migrants do not wander far longitudinally; this assumption seems supported by anecdotal observations (Bent 1961).

Data were analyzed using SAS procedures (SAS 1982). All statements concerning statistical significance refer to $P<0.05$. I standardized hawk counts by party-hr and party-km for all analyses (Raynor 1975). Results were similar regardless of the standardizing factor; thus, I only present the numerical results using party-hr. Because of potential problems when raw ratios are used in some statistical tests (Atchley et al. 1976, Anderson 1977), the standardizations were done by taking the difference between logarithms, e.g., log10 (number of Red-tails) - log10 (number of party-hr) = log10 (number of Red-tails/number of party-hr). To avoid omitting zero counts (i.e., the logarithm is undefined), I added 0.5 to all counts before performing the tests.

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The hawk abundance datasets differed significantly from normal even after transformation. The Spearman rank correlation method was therefore used to test for correlations (r_s) between year and hawk abundance. These nonparametric tests were applied to the data for individual CBCs, not to yearly means.

I used analysis of covariance (Kachigan 1986) to test for additional effects of latitude, longitude, and count weather. Preliminary analyses indicated no significant interactions between weather and year, latitude or longitude. Since this approach draws on analysis of variance, which assumes normal distributions, the results can only be considered approximate. Where significant effects of weather were detected, the direction of the effect was determined by a "least-squares mean" analysis, that controls for the influence of other variables (SAS 1982). Significant effects of latitude and longitude, independent of year and weather, were investigated by computation of Spearman correlations within years for counts reporting clear weather (the majority of CBCs).

Spearman rank correlations were computed for yearly mean hawk abundances versus mean November and December temperatures at the locations listed above. In addition, multiple regressions were computed with yearly mean hawk abundances as the criterion variables and yearly means for CBC latitude, CBC longitude, and temperature of the four locations as predictor variables.

Results and Discussion

Red-shouldered Hawks were recorded more commonly than Red-tailed Hawks in all years. Both species tended to decline from the late 1940's until 1957 (Figure 1). The correlation for Red-tail abundances versus year for 1946-1957 was -0.23 ($P = 0.002$, N = 190 CBCs); for Red-shoulders it was -0.13 ($P = 0.085$, N = 190 CBCs). From 1957 to 1983, Red-shoulder abundances showed no trend ($r_s = +0.03$, $P = 0.337$, N = 869 CBCs), but Red-tail numbers increased significantly ($r_s = +0.32$, $P < 0.001$, N = 869 CBCs). At the lowest extreme in 1957, an average of three Red-tails were seen per 100 party-hr; by 1981, an average of 23 Red-tails were counted per 100 party-hr.

The pattern of decline and then stability for Red-shoulders coincides with Brown's (1972) summary for this species in the southeast United States through 1969, but the increasing trend in the Red-tail numbers has not been previously documented. Over the years there were increases in the number of Florida CBCs (minimum 8 in 1947, maximum 42 in 1982), in the average party-hr per CBC (minimum 21.2 in 1946, maximum 111.2 in 1977), and in the average party-km per CBC (minimum 86.5 in 1946, maximum 679.1 in 1976); but, these changes are factored out through the standardization procedures. The analysis of covariance allows investigation of some other effects that might explain the trend. The results (Table 1) show that, depending on the time span treated, there were sometimes significant effects of CBC latitude, longitude, and weather on reported hawk numbers. However, all analyses still showed a significant effect of year on Red-tail abundances, independent of the other variables. The significant effect of year on Red-shoulder numbers for the entire period is apparently primarily due to the earlier

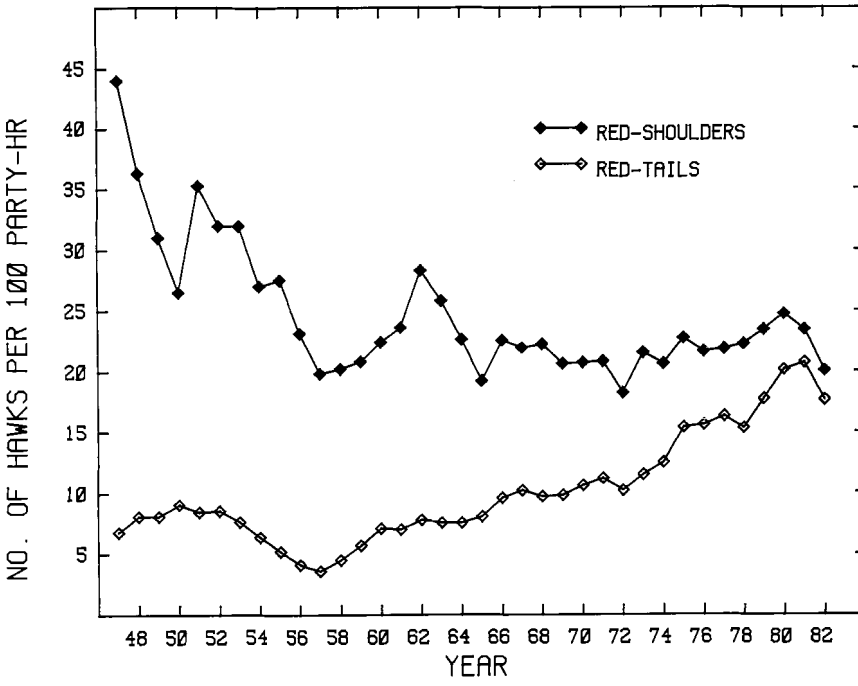

Figure 1. Three-year moving means of Red-tailed and Red-shouldered hawks per 100 party-hr on Florida CBCs 1947-1982.

years of decline, since the effect is not significant when years 1957-1983 are treated separately.

The effects of CBC latitude and longitude, which are significant for both species, must be fairly subtle. Correlation analyses performed separately by year, and controlling for weather, indicate only that Red-tail numbers were strongly related to latitude (Table 2). The change in Red-tail numbers over the years might have been attributable entirely to changes in the mean CBC latitude if the two variables varied in close synchrony. The mean latitude of Florida CBCs does show a decline and then an increase (Figure 2). However, the lowest average CBC latitude in Florida was reached in 1962 when Red-tail numbers already had been increasing for about five years. Hence, the multivariate analysis indicates an effect of year independent of latitude's effect.

Where the effect of count weather was significant, means adjusted for the other covariates indicated that relatively fewer hawks were reported on overcast than on clear days, a predictable result. The bivariate correlation analysis showed that autumn temperatures (November, in particular) only had a significant effect on Red-shoulder numbers. However, when latitude and longitude also were taken into account using

Table 1. Analysis of covariance for number of Red-tailed (RT) and Red-shouldered (RS) hawks per party-hr (PH) versus four variables. Sum of squares, with associated F and P values, indicates a variable's effect independent of the others. Significant effects are marked with an asterisk.

	Criterion variable	Predictor variable	Type IV sum of squares	F	P>F
1946-1957	RT per PH	year*	1.04	6.00	0.015
(N=187 CBCs)		latitude*	9.17	52.99	<0.001
		longitude*	1.44	8.34	0.004
		weather	0.01	0.06	0.809
	RS per PH	year*	1.28	5.82	0.017
		latitude	0.19	0.86	0.355
		longitude	0.84	3.83	0.052
		weather	0.14	0.64	0.424
1957-1983	RT per PH	year*	13.34	81.77	<0.001
(N=859 CBCs)		latitude*	79.87	489.77	<0.001
		longitude*	23.26	142.6	<0.001
		weather*	1.36	8.34	0.004
	RS per PH	year	0.13	0.67	0.412
		latitude*	1.72	9.08	0.003
		longitude*	5.47	28.91	<0.001
		weather*	1.25	6.61	0.010
1946-1983	RT per PH	year*	13.81	81.31	<0.001
(N=1027 CBCs)		latitude*	90.95	535.39	<0.001
		longitude*	23.25	136.86	<0.001
		weather*	1.10	6.48	0.011
	RS per PH	year*	0.86	4.38	0.036
		latitude*	1.15	6.31	0.016
		longitude*	6.31	32.03	<0.001
		weather	0.56	2.87	0.091

multiple regression, the effects of these temperatures were no longer significant, even for Red-shoulders (Table 3).

It seems doubtful that there could have been a change in skill or behavior of CBC participants since the mid-1950's that raised only Red-tail counts. In conjunction with the preceding statistical results, the increase in Red-tail numbers thus appears not to be an artifact of CBC circumstances, but rather to reflect real population changes.

The early declines might be attributable to habitat alteration (Henny et al. 1973) or to pesticide usage (Hickey and Anderson 1968). However, CBC numbers for the two hawk species did not show dramatic responses to bans on DDT and dieldrin in 1972 and 1974, respectively (Figure 1), though this may be because of the persistence of those substances (Johnston 1978, Sundlof et al. 1986). In any case, there is no obvious link

Table 2. Summary of Spearman rank correlations for numbers of Red-tailed (RT) and Red-shouldered (RS) hawks per party-hr (PH) versus CBC latitude and longitude in Florida, computed separately for each year: 1946-1983.[1] Entries are the number of years in which correlations of each type were observed.

Correlation results	RT per PH vs. latitude	RT per PH vs. longitude	RS per PH vs. latitude	RS per PH vs. longitude
Significant, positive	25	1	0	3
Not significant, positive	11	17	20	17
Significant, negative	0	0	0	0
Not significant, negative	2	20	18	18

[1]Computed only for CBCs with clear weather.

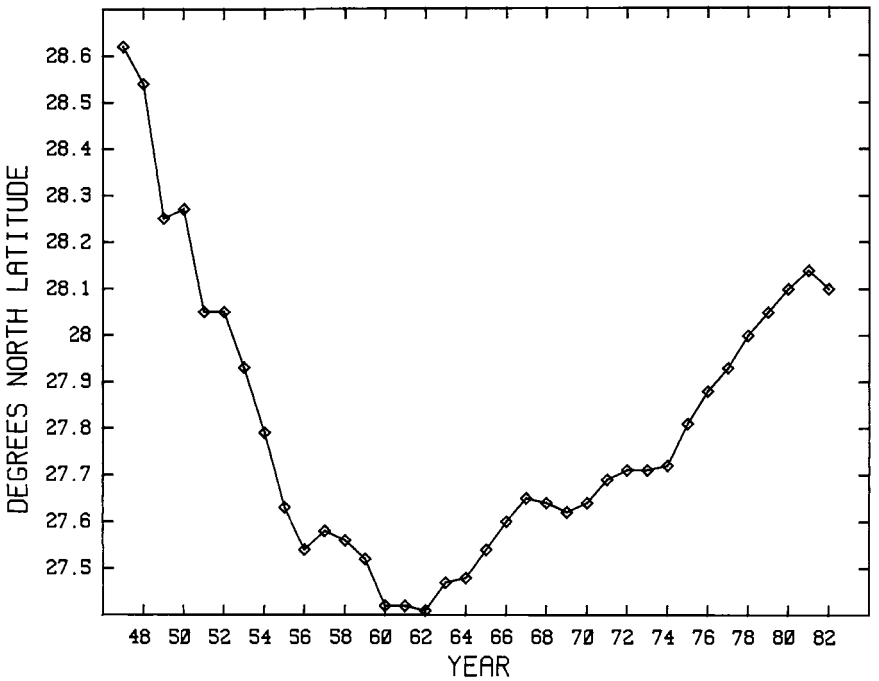

Figure 2. Three-year moving means of latitude for Florida CBCs 1947-1982.

between pesticides and the cessation of the Red-shoulder decline in the mid-1950's, or the reversal of the Red-tail decline at that time.

Because winter populations in Florida are swelled by migrants (Layne et al. 1977, Bohall and Collopy 1984), the Red-tail CBC increase may reflect improved reproductive success outside of Florida or heightened

Table 3. Multiple regression analyses for average yearly number of Red-tailed (RT) and Red-shouldered (RS) hawks per party-hr (PH). November temperature is average temperature of the four localities listed in Methods during November preceding the CBCs, and December temperature is the corresponding average for December. Similar results were obtained when year was included as a predictor variable. N = 30 yearly averages (1950-1980) in all cases.[1] Significant effects are marked by an asterisk.

Criterion variable	Predictor variable	Parameter estimate	T	P>T
RT per PH	Latitude*	0.777	4.73	<0.001
	Longitude*	-0.580	-2.90	0.008
	Nov. temp.	-0.005	-0.28	0.781
RT per PH	Latitude*	0.806	4.92	<0.001
	Longitude*	-0.599	-3.05	0.005
	Dec. temp.	-0.012	-1.03	0.311
RS per PH	Latitude	-0.060	-0.52	0.609
	Longitude	0.284	2.01	0.055
	Nov. temp.	-0.020	-1.71	0.099
RS per PH	Latitude	-0.038	-0.32	0.754
	Longitude	0.288	2.00	0.056
	Dec. temp.	-0.012	-1.36	0.187

[1]Weather data for 1969 were not available.

attractiveness of Florida habitats in winter. The importance of migrants is suggested by comparing the CBC results to Florida data of the Breeding Bird Survey (S. Droege, pers. comm.). These surveys are conducted in summer, and have taken place since 1966. Neither Red-tails nor Red-shoulders have shown consistent increasing or decreasing trends in these surveys. The Red-tail CBC increase since 1966 can thus be attributed to more winter migrants.

Differing CBC trends for the two hawk species over the last 30 years may reflect differences in their habitat affinities (e.g. see Bent 1961, Bohall and Collopy 1984). Deforestation may have made Florida more attractive for wintering Red-tails, while conditions have not improved for Red-shoulders, which are often associated with wetlands. Deforestation in other states also could have improved Red-tail reproductive success, which would increase the number of winter migrants to Florida. Widespread improvement in Red-tail reproductive success is supported by the observation that CBC results for Red-tails have been greater in the 1980's than in the 1970's for the United States as a whole (Fuller et al. 1986).

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